

Biogenic Synthesis of Engineered Platinum Nanomaterial: A Review

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Abstract: Recently, nanomaterials have much attention due to their variety of applications such as energy storage devices, electronic and optical displays, manufacturing of advanced materials, super computers, catalysis, chemical and biosensors. Various approaches were developed for the synthesis of Pt NPs by different methods such as sol-gel route, chemical precipitation, pyrolysis, hydrothermal synthesis, sol process, vapor deposition and electro-deposition. Biogenic synthesis of platinum (Pt) nanoparticles has captured the attention of many researchers because it is economical, sustainable and eco-friendly. So in the present review Biogenic syntheses of Pt nanoparticle by the utilization of biological agents like bacterium, fungi, plants and animal was employed. The bacterial agents like *Acinetobacter calcoaceticus*, *Desulfovibrio vulgaris*, *Plectonema boryanum*, and *Shewanella alga*, fungal agents like *Fusarium oxysporum*, *Fusarium oxysporum* f. sp. *lycopersici*, and *Neurospora crassa* plants like *Anacardium occidentale*, *Azadirachta indica*, *Cacumen Platycladi*, *Camellia sinensis*, *Cerbera manghas*, *Cochlospermum gossypium*, *Diopyros kaki*, *Fumariae herba*, *Lantana camara*, *Ocimum sanctum*, *Prunus yedoensis*, *Quercus glauca*, *Terminalia chebula* plant materials like wood, natural lignin, fulvic acid and animal substances like Quail egg yolk and sheep milk was used.

Keywords: Engineered Nanomaterials, Biogenic, platinum, Mycosynthesis, Phytofabrication

D. INTRODUCTION:

Nanotechnology is gaining tremendous impetus within the gift century owing to its capability of modulating metals into their nanosize. Analysis in applied science highlights the likelihood of inexperienced chemistry pathways to supply technologically necessary nanomaterials (8,18). Nanoparticles may be synthesized totally different approaches together with a chemical, physical and biological ways. Though chemical methodology needs short duration for the synthesis of huge amount of nanoparticles, this methodology needs capping agents for size stabilization of the nanoparticles. Chemicals used for nanoparticles synthesis and stabilization show cytotoxic effect and produce non-ecofriendly byproducts. The necessity for environmental non-toxic artificial protocols for nanoparticles synthesis results in developing interest towards biological approaches that measure free from the employment of cytotoxic chemicals as byproducts. Thus, there is increasing demand for “green nanotechnology” (7). The most important aim of green nanotechnology is to reduce the employment of cytotoxic chemicals there by atmosphere free from pollution. There are 3 main conditions for nanomaterials preparation (i) the selection of environment-friendly solvent medium, (ii) reducer and (iii) a nontoxic material for their stabilization. Therefore, totally different biological sources were accustomed to synthesize Platinum nanomaterials.

Platinum nanoparticles (PtNPs) are thought of important in space of analysis owing to their distinctive and tuneable Surface Plasmon Resonance (SPR). Platinum metal as catalysts allows power generation in electric cell vehicles, electrocatalysis and chemical synthesis (silver-platinum nanoparticles) as a magnetic nanopowder and throws out on silicon oxide and carbon nanotubes. Platinum nanoparticles are employed in medical specialty applications in mix with nanoparticles of alternative metals, in alloy, core-shell, or bimetallic nanocluster forms (1). Yolk-shell nanocrystals of FePt@CoS₂ are found to be extremely effective in killing Hela cells when put next to cis-platin (6). Cis-diaminedichloroplatinum (Cis-platin) associate degreed noble metal based mostly advanced [FePt@CoS₂] are used generally as an antitumor medication (5). As designed Platinum metal materials have wide applications it gains importance in gift century that the biogenic synthesis of platinum nanomaterial was reviewed.

II. BIOGENIC SYNTHESIS OF PLATINUM:

The chemical science and optoelectronic properties of metallic nanoparticles are powerfully dependent on the dimensions and size-distribution, however conjointly nanoparticles form contributes considerably to the management of their properties. Wide kinds of physical and chemical procedures are developed to synthesize nanoparticles of various compositions, sizes, shapes and controlled polydispersity. Biological artificial processes have emerged as a straightforward and viable different to a lot of complicated chemical science approaches to get nanomaterials with adequate management of size and form (21). Biosynthetic ways using biological microorganisms, plant extracts and animal sources have emerged as straightforward, viable alternate to chemical procedure and physical ways (29). Indeed, over the past many years, plants, algae, fungi, bacterium and viruses are used for low-priced, energy economical and non-toxic production of metallic nanoparticles (27). The biological ways are cheap and eco-friendly route for synthesis of nanoparticles. The syntheses of Pt nanoparticle are incontestable by the utilization of biological agents like bacterium, fungi, plants and animal.

III. BACTERIAL SYNTHESIS OF PLATINUM:

Acinetobacter calcoaceticus PUCM 1011 with efficiency synthesized animate thing noble metal nanoparticles (PtNP) of size 2–3 nm once challenged with hexachloroplatinic acid. Salt concentration (1 mM), temperature (30 °C), pH scale (7) and time period (72 h) influenced the potency of mono disperse cubiform PtNP synthesis (4). Biological synthesis of noble metal nanoparticles (Bio-Pt) has been reportable, explored the potential of cell-supported noble metal (Bio-Pt) nanoparticles synthesized with *Desulfovibrio vulgaris* as biocatalysts (14). Interaction of eubacterium (*Plectonema boryanum* UTEX 485) with liquid noble metal (IV) –chloride (PtCl₄) has been investigated at 25–100 ° C for up to 28 days and 108°C for one day. The addition of PtCl₄ to the eubacterium culture ab initio promoted the precipitation of Pt(II)–organic material as amorphous spherical nanoparticles (≤0.3 μm) in solutions and spread nanoparticles among microorganism cells. The spherical Pt(II) organic nanoparticles were connected into long buttony chains by an eternal coating of organic material derived from the cyanophyte cells, and aged to nanoparticles of a crystalline Pt metal with increase in temperature and interval (11). The bioreduction of noble metal nanoparticles occurred by the resting cells of the metal ion-reducing bacteria *Shewanella alga*. The noble metal deposition method by particle reducers occurred in 2 steps (1) uptake of PtCl₆²⁻ ions from the solution into the periplasmic area and (2) the protein reduction of PtCl₆²⁻ ions into elemental noble metal with nurse because the electron donor (32).

IV. MYCOSYNTHESIS OF PLATINUM:

Mycosynthesis of Pt is healthier and eco-friendly. Therefore, the *Fusarium oxysporum* once incubated with hexachloroplatinic acid (H₂PtCl₆) in close conditions reduces the precursor and ends up in the formation of stable living thing Pt nanoparticles (26). Riddin et al. (20) incontestable Response Surface Methodology (RSM) that consists of a central style to work out the best conditions like temperature, hydrogen ion concentration and concentration of gas hexachloroplatinate (H₂PtCl₆) for the synthesis of Pt nanoparticles by *Fusarium oxysporum* f. sp. *lycopersici* Pt Nanoparticles of variable size (10–100 nm) and form (hexagons, pentagons, circles, squares, rectangles) were made at each living thing and living thing levels by the *Fusarium oxysporum* f. sp. *lycopersici*. The Pt nanoparticle formation was ascertained for an amount of seventy-two hours for any color amendment from yellow to dark brown (20). Fungal biomass and fungal extract of the nonpathogenic fungus *Neurospora crassa* were successfully used as reducing agents for the biosynthesis of platinum nanoparticles (PtNPs). The experiment was carried out by exposing the fungal biomass or the fungal extract to a 0.001 M precursor solution of hexachloroplatinic (IV) acid (H₂PtCl₆). A change of color of the biomass from pale yellow to dark brown was the first indication of possible formation of PtNPs by the fungus. Subsequent analyses confirmed the intracellular biosynthesis of single PtNPs (4-35 nm in diameter) and spherical nanoaggregates (20-110 nm in diameter). (13).

V. PHYTOFABRICATION OF PLATINUM:

An Eco-friendly approach for the synthesis of platinum nanoparticles (NPs) with dried leaf powder of *Anacardium occidentale* is reported. FTIR spectra reveal that proteins are responsible for synthesis of platinum nanoparticles. TEM pictures show irregular rod shaped particles that are crystalline. Synthesized NPs exhibit chemical activity within the reduction of aromatic nitrocompound. The effective thermal physical phenomenon of synthesized Pt/water nanofluid has been measured and located to be increased to an honest extent. (23). Thirumurugan et al. (28) have reported the biosynthesis of platinum nanoparticles from *Azadirachta indica* extract. The speed of platinum metal nanoparticle fabrication was raised with rise in the reaction temperature. *A. indica* leaf broth was believed to contain the terpenoids that act as reducer and as stabilizer for the nanoparticles synthesis. TEM studies indicated the formation of polydispersed nanoparticles of tiny to giant spheres (5–50 nm). Biologically synthesized Pt nanoparticles (PtNPs) by reducing Na₂PtCl₄ with *Cacumen platycladi* Extract (CPE)) was attributed by reducing sugars and flavonoids instead of proteins (33)

In green tea (*Camellia sinensis*) the gallic acid has used to obtain water soluble Pt nanostructures, and has proved to be an efficient capping agent of Platinum nanoparticles synthesis. In case of platinum nanoparticles, when time reaction increased, the color of solution gradually changed from yellow brown to dark brown. The Platinum nanoparticles obtained by bioreduction with *Camellia sinensis* liquid extract, shown principally spherical morphology with a size between 2-10 nm. (16). Biological synthesis of Platinum nanoparticles by leaves of *Cerbera manghas* extract through an green route was reported during this study. TEM image shows all particles were in spherical form with size starting from 9.60 nm to 11.70 nm. The nanoparticles were crystalline in nature. From the FTIR measurements it absolutely was detected that reduction has been applied by carboxyl and alcoholic groups within the leaves of *C. Manghas* (19). Green synthesis method using plant derived natural product (gum kondagogu) *Cochlospermum gossypium* for synthesis of platinum nanoparticles was reported. FTIR analysis indicates that –OH groups present in the gum matrix were responsible for the reduction of metal cations into nanoparticles. TEM analysis shown Pt nanoparticles were in the size range of 2.4 ± 0.7 nm (31).

The leaf extract of *Diopyros kaki* was used as a chemical agent for the ecofriendly synthesis of Pt nanoparticles from a binary compound H₂PtCl₆·6H₂O. A larger than ninetieth conversion of Pt ions to nanoparticles was achieved with a reaction temperature of 95°C and a leaf broth concentration of [10%]. The typical particle size ranged from two to twelve nm counting on the reaction temperature and concentrations of the leaf broth and PtCl₆²⁻ (24). Due to the increasing technology of using plant extract in the synthesis of nanoparticles, the synthesis of platinum nanoparticles using *Fumariae herba* extract was studied. Platinum nanoparticles presented good catalytic properties in the reduction of methylene blue and crystal violet (3).

A rapid, duplicatable single step methodology is projected for synthesizing Pt nanoparticles exploitation of invasive weed and poisonous plant (*Lantana camara*. L). The tactic involves mix of Pt (VI) answer, poisonous plant leaf extract and vitamin C in applicable concentrations and keeping the mixture at 95°C for eight-min. The collective action of vitamin C and leaf extract reduced the chloroplatinic acid to Pt nanoparticles and leaf extract then served the extra purpose of stabilising the nanoparticles. The ensuing nanoparticles have a mean size of thirty-five nm and crystallized in face centered three-dimensional symmetry (15). Biosynthesis of Pt nanoparticle pellets exploitation asterid dicot plant *Ocimum sanctum* leaf broth was achieved at one-hundred °C in one h. The reduction was quantitative and known by a modification in color from yellow to brown and at last black. Vitamin C and terpenoids are a unit noted to be gift within the *Ocimum sanctum* leaf extracts that act as reducing moreover as stabilizing agents (25). Green synthesis of Pt nanoparticles (PtNPs) exploitation of *Prunus yedoensis* tree gum extract was studied. Transmission Electron microscopy shows that PtNPs are a unit principally spherical and oval in form, with a mean particle size of ten to fifty nm. Chemical constituents' gift within the gum extract is also accountable for the reduction of platinum particle. Among the 5 phytopathogens tested, the 2 pathogens *Colletotrichum acutatum* and *Cladosporium fulvum* show fifteen millimetre and eighteen millimetre zones of inhibition against synthesized PtNPs at four and eight µg/well, severally (30).

Facile, fast and eco-friendly synthesis of Platinum nanoparticles (Pt NPs) mistreatment liquid leaves extract of hamamelid dicot plant *Quercus glauca* (Qg) has been reportable for 1st time to detection of environmental and human toxic reducer. The ready platinum NPs were around spherical in form and therefore the size vary from 5-15 nm. The platinum NPs changed GCE shows a pointy peak at an awfully lower onset reaction potential -0.3 V. The invented reducer sensing element showed terribly lower detection limit, wide linear vary, smart sensitivity and wonderful property of seven nm, 0.01 to 283 µM, and 1.704 µA/µM/ cm² severally. The inexperienced synthesized platinum NPs changed GCE sensing element was with success used for the detection of reducer (Spiked) in varied water samples (9). A straightforward one step inexperienced synthesis of noble metal nanoparticles mistreatment present plant polyphenols obtained from Associate in nursing liquid extract of *Terminalia chebula*. No surfactant/stabilise agent was used during this technique. All the noble metal nanoparticles obtained was within the size vary of but four nm (10).

Lin et al (12) report a environment-friendly synthesis of Platinum nanoparticles with controlled shapes and sizes using wood nanomaterials in liquid section while not using the other reductants, capping or dispersing agents. This green method affords a simple route to the assembly of shape-selective metal nanoparticles. The obtained spherical and isometric platinum nanoparticles and spherical platinum nanoclusters exhibit high activities within the chemical change reduction of p-nitrophenol as a model reaction. Green synthesis of platinum nanoparticles has been reported from natural lignin and fulvic acid in aqueous phase at pH 7 at 80 °C under aerobic conditions. These polymers act both as reducing and stabilizing agents. The formation of platinum nanoparticles with lignin was change in colour from orange to dark brown. The formation of platinum nanoparticles with fulvic acid showed a band at 280 nm due to the presence of phenolic group in it. The NMR spectra showed the presence of PtCl₆²⁻ and PtCl₅(H₂O)⁻ species which slowly disappear as a result of the formation of nanoparticles (2).

VI. ANIMALS SUBSTANCES MEDIATED SYNTHESIS OF PLATINUM:

Green synthesis of platinum nanoparticles by reaction mixture of Quail egg yolk having high vitamin and protein content was prepared. The highest platinum nanoparticles were synthesised at 20 °C and pH 6.0 for 4 h. Also, optimal concentration of metal ions was established as 0.5 mM (17). Green synthesis of platinum nanoparticles (PtNPs) using sheep milk is reported for the first time by adjusting the concentrations of chloroplatinic acid (H₂PtCl₆) and milk in aqueous solutions, spherical PtNPs were obtained at room temperature. The spherical particles obtained have an average size 9.0 nm as shown by XRD pattern and TEM analysis (22)

Table1: Biogenic synthesis of platinum nanoparticle by living organisms

S. No	Organism	Substrate	Mode of synthesis	Nano particles	Reference
1	Acinetobacter calcoaceticus	Bacterial extract	Intercellular	Pt	(4)
2	Desulfovibrio vulgaris	Bacterial extract	Extracellular	Pt	(14)
3	Shewanella algae	Bacterium extract	Extracellular	Pt	(32)
4	Plectonema boryanum	Cyanobacteria cells	Extracellular intracellular	Pt	(11)
5	<i>Fusarium oxysporum f. sp. lycopersici</i>	Fungal extract	extracellular intercellular	Pt	(20)
6	<i>Fusarium oxysporum</i>	Fungal extract	Extracellular	Pt	(26)
7	Neurospora crassa	Fungal extract	Extracellular/inter cellular	Pt	(13)
8	Anacardium occidentale	dried leaf powder	Extracellular	Pt	(23)
9	Azadirachta indica	leaf extract	Extracellular	Pt	(28)
10	Cacumen Platycladi	Leaf Extract	Extracellular	Pt	(33)
11	Camellia sinensis	Tea extract	Extracellular intracellular	Pt	(16)

12	Cerbera manghas	leaves extract	Extracellular	Pt	(19)
13	Cochlospermum gossypium	gum kondagogu	Extracellular	Pt	(31)
14	Diopyros kaki	Leaf extract	Extracellular	Pt	(24)
15	Fumariae herba	Plant extract	Extracellular	Pt	(3)
16	Lantana camara, L	weed leaf extract	Extracellular	Pt	(15)
17	Ocimum sanctum	leaf broth	Extracellular	Pt	(25)
18	Prunus yedoensis	tree gum extract	Extracellular	Pt	(30)
19	Quercus glauca	leaves extract	Extracellular	Pt	(9)
20	Terminalia chebula	Polyphenol	Extracellular	Pt	(10)
21	wood	Wood components	Extracellular	Pt	(12)
22	Natural aromatic polymers	natural lignin fulvic acid	Extracellular	Pt	(2)
23	quail	egg yolk	Extracellular	Pt	(17)
24	sheep	sheep milk	Extracellular	Pt	(22)

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